

Immature Atlantic Loggerhead Turtles (*Caretta caretta*): Suggested Changes to the Life History Model

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North Atlantic loggerhead turtle (*Caretta caretta*) populations have extended and complex developmental life histories. Hatchling loggerheads enter the surf and find their way into the pelagic environment where they remain for several years before returning to coastal waters (Musick and Limpus 1997). Carr (1986, 1987) hypothesized that loggerhead hatchlings from the large Florida rookeries become entrained in major current systems (e.g., Gulf Stream) and are passively transported to the eastern Atlantic, and eventually return to the western Atlantic via the North Atlantic gyre. Carr's hypothesis was supported by genetic evidence that immature eastern Atlantic (Azores Islands) loggerheads originated from western Atlantic rookeries (Bolten et al. 1998). These immature turtles are then thought to recruit from pelagic (oceanic) habitats to coastal habitats, migrating north and south along the U.S. east coast sea-

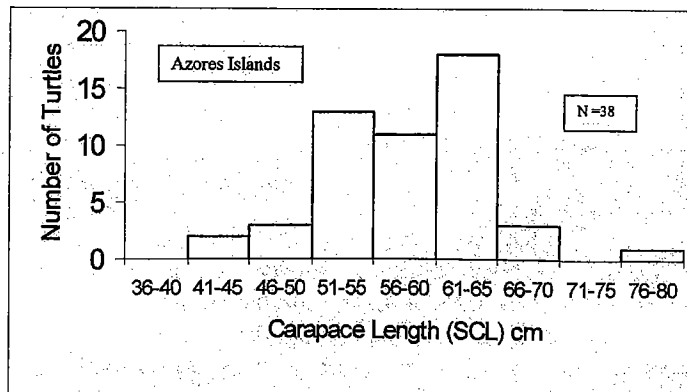
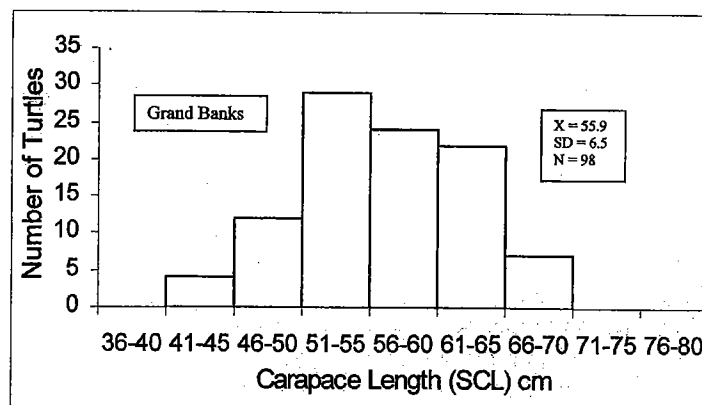


FIG. 1. Carapace lengths of Grand Banks (Witzell 1999) and Azores (Bolten et al. 1994) longline caught turtles.

sonally (Musick and Limpus 1997). The Florida turtles mature after several years in coastal habitats and nest at about 92 cm straight carapace length (SCL) (Bjorndal et al. 1983). However, there are pelagic length frequency data and flipper tag recapture data, satellite telemetry and aerial survey data, and historical evidence that suggest the popular conceptual models of loggerhead turtle life histories might be more complicated than previously thought.

Carapace length data from stranded turtles along the U.S. Atlantic coast have been used to estimate the size that immature turtles leave the pelagic habitat and enter coastal waters. Stranding data indicate that this settlement size ranged from 25 to 30 cm curved carapace length (CCL) (Musick and Limpus 1997) to 40–60 cm SCL (Carr 1986, 1987; Martin et al. 1989). Bjorndal et al. (2000, 2001) hypothesized from growth data that most eastern Atlantic (Azores Islands) juvenile turtles depart the eastern Atlantic pelagic habitat and recruit to the coastal U.S. habitats between 46 and 53 cm CCL. They also hypothesized that almost all eastern Atlantic loggerheads left the pelagic habitat by 64 cm CCL (presumably to the western Atlantic). Analysis of growth layers in bone sections from stranded turtles has suggested that Atlantic loggerhead turtles might settle out of the pelagic habitat to coastal habitats at 52.0 cm SCL (Snover et al. 2000). An apparent shift in growth layer patterns, termed “settlement lines,” theoretically represented the shift from pelagic to coastal habitats. However, dietary analysis suggests that immature loggerhead turtles in the Mediterranean Sea did not permanently settle into coastal waters immediately, but moved back and forth from pelagic to coastal benthic habitats for an undetermined time before settling down (Laurent et al. 1998). Perhaps the extended settlement size range of North Atlantic loggerheads (25–64 cm CCL) lends support to an intermediary developmental phase as hypothesized for the Mediterranean by Laurent et al. (1998).

This flexible shift from strictly pelagic to coastal habitats might also occur in the western Atlantic loggerhead populations. Some immature turtles might stay in the pelagic habitat in the North Atlantic longer than hypothesized, and some turtles might move back and forth between pelagic and coastal foraging habitats. Witzell (1999) reported that the mean (\pm SD) size of loggerheads caught incidentally by swordfishermen east of the Grand Banks in the north central Atlantic was 55.9 ± 6.5 cm CCL (range = 41–70 cm). Some of these pelagic turtles (11.2%) are close to, or larger than (> 64 cm CCL), the hypothesized settlement sizes when most loggerhead juveniles are assumed to become coastal benthic for-



FIG. 2. German submarine crew members of U-92 pose with large immature loggerhead turtle under the anti-aircraft cannon near the Azores Islands in December 1942. Photo courtesy G. Sytko.

agers. The turtles captured near the Grand Banks appear similar to those turtles reported by Bolten et al. (1993) from the Azores (Fig. 1). Bolten et al. (1993, 1994) also encountered some “post-settlement size” (55–80 cm CCL) turtles near the Azores, turtles that were possibly “loafers” or coastal-pelagic “commuters.” Some of these turtles are clearly larger than the size range recruiting to coastal benthic habitats, and either stayed in the pelagic habitat, or they returned from the coastal habitat. The turtles that have stayed in the pelagic habitat might be “late bloomers” and are on the verge of settling into coastal habitats. Two turtles tagged aboard swordfish vessels (61.2 cm and 60 cm CCL) on the Grand Banks were recaptured in U.S. coastal waters, and were possibly settling into the coastal habitats (Witzell 1999). One turtle was recovered in North Carolina and the other turtle from west Florida.

There is also evidence that some of these “coastal” and “pelagic” turtles might move long distances and switch between the coastal and pelagic foraging habitats. Large immature loggerheads might make trans-Atlantic movements. A 73.1 cm SCL loggerhead moved from Cape Canaveral, Florida, 5140 km east to the Azores Islands in 18 months (Eckert and Martins 1989). Another turtle (84.0 cm SCL), tagged in the Canary Islands in the eastern Atlantic, moved west 6900 km to Cuba in 5 months (Bolten et al. 1992). Four immature loggerheads (33.9–57.6 cm) satellite tagged at Madeira in the spring moved northwest against the prevailing currents (Dellinger and Freitas 2000). One of these turtles moved over 3000 km northwest to the Grand Banks (45°N, 40°W). Additionally, Morreale (1999) reported two satellite tagged loggerheads that migrated south along the U.S. east coast before moving thousands of kilometers offshore southeast of the Grand Banks. The first turtle (59.1 cm SCL) was tagged in Long Island Sound, New York, in October and moved south to Cape Hatteras before moving northeast in the Gulf Stream a distance of 1800 km. The second turtle (52.2 cm SCL) was also satellite tagged in Long Island Sound, New York, in October and moved south to Cape Lookout, North Carolina, before moving northeast a distance of 2360 km.

Furthermore, by combining aerial survey observations off the U.S. east coast (Shoop and Kenney 1992) and U.S. pelagic longline fleet captures (Witzell 1999), we know that large loggerhead turtles (mature and/or immature) routinely inhabit offshore habitats during non-winter months in the northwest North Atlantic Ocean. Some of these turtles might be associated with warm water fronts



FIG. 3. Carapace of large loggerhead sea turtle tied to the barrel of an 88 mm cannon aboard a German submarine in World War II. Photo from the U.S. National Archives and Records Administration, Washington, D.C.

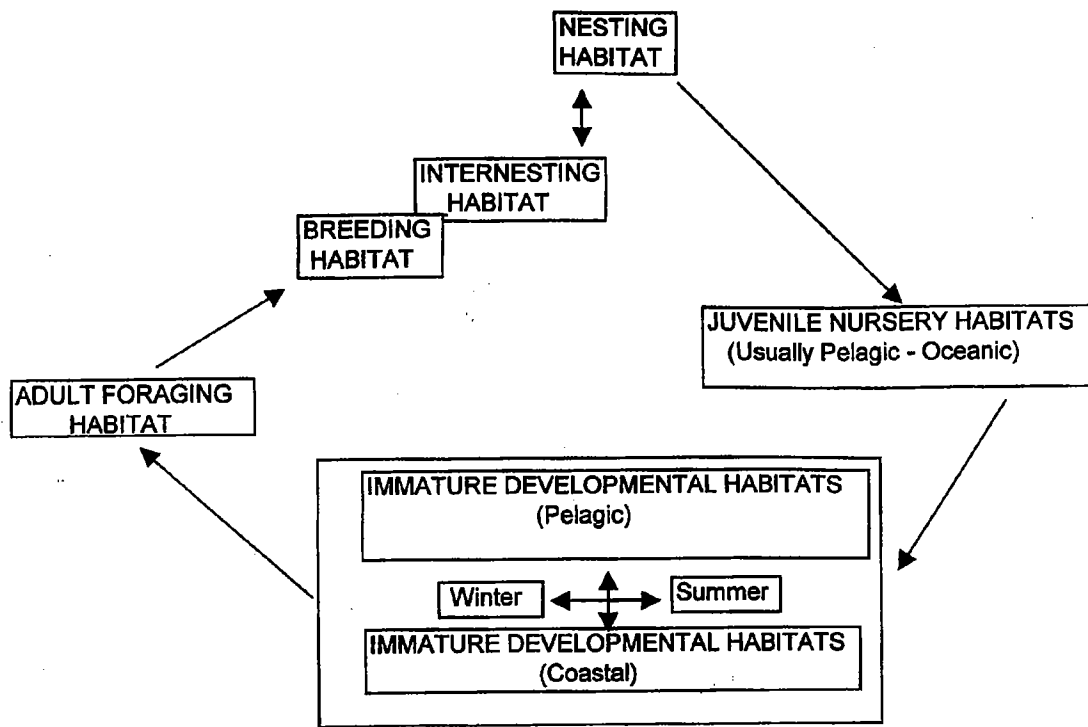


FIG. 4. Proposed conceptual model of loggerhead turtle development, showing seasonal movements between pelagic and coastal developmental habitats (modified after Musick and Limpus 1997).

and eddies associated with oceanic current systems such as the Gulf Stream and might form offshore feeding aggregations in areas of high productivity (Witzell 1999).

Historically, large immature pelagic loggerhead turtles were seemingly abundant between the Grand Banks and the Azores 50 years ago, before the declines in loggerhead turtle population of the 1970's (National Research Council 1990). German submarines reported seeing many large turtles swimming near their submarines during World War II near the Azores Islands (Wiggins 1999). While waiting for allied merchant shipping, crewmen would dive into the water after sundown, tie ropes to the turtles, and then pull them onto the U-boat deck. It is estimated from the photos that these turtles were approximately 65–75 cm (Figs. 2 and 3). The meat was used to make soups and the shells were kept as souvenirs.

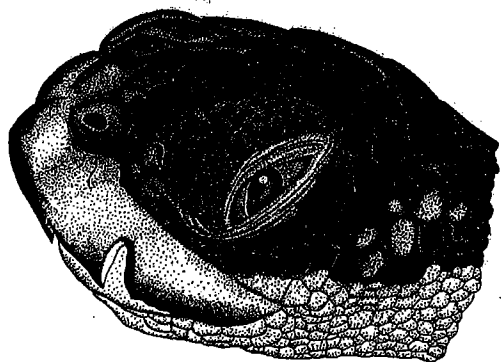
Loggerhead turtles apparently have very complex life histories involving different developmental habitats. Australian loggerheads reportedly settle out of pelagic habitats at near mature sizes (79.8 cm SCL) and become residents of coastal feeding aggregations (Limpus et al. 1994). However, in the North Atlantic, the existence of later-stage immature pelagic loggerhead turtles either staying in or moving between coastal and pelagic habitats in the northwestern North Atlantic suggests the possible need for refinements to the current conceptual developmental models of Miller (1997) and Musick and Limpus (1997). The proposed new model is modified after Musick and Limpus (1997) and includes the addition of probable seasonal movements of immature turtles between pelagic and coastal developmental habitats (Fig. 4). Commonly used terms such as "coastal benthic" and "settlement lines" might be misleading and should be revised or used with caution.

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Dermochelys coriacea (Leatherback Seaturtle) hatchling (FAU, uncat.).
USA: Florida, Palm Beach Co. Illustration by Julian C. Lee.